Determinants of Variations in Fish Catch Levels in Artisanal Fishing of Lagos State, Nigeria

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Abstract: Catch levels in artisanal fisheries of Lagos state vary according to the fishing zones, technologies and seasons. This study therefore examined the major determinants of these variations and their effects on fish catch levels among the artisanal fishing households in the state. A total of 222 artisanal fisherfolks comprising of 120 operators of manual propulsion fisheries (MPF) and 102 operators of motorized fisheries (MF) were sampled for the study. Results showed that educated fisherfolks have greater likelihood of understanding the working mechanism of the motorized engines and therefore should be able to use it more. Fishing distance is another important variable that could determine the use (or otherwise) of motorized fisheries technology among the artisanal fisherfolks of Lagos state. Fisherfolks generally want to reach out far into the water/sea to be able to make good catches. This is important because the nearby coastal waters are usually over-exploited and therefore depleted. The availability of credit facilities for the use of the artisanal fisherfolks could also increase the likelihood of their adopting the use of outboard engines as against the use of traditional, manual-propelled boats/canoes. For the ML catch frontier for MF labour (x_l) and fuel (x_f) are positively significant at 1% level while credit (x_c) and ice block (x_i) are significant at 5% level. Quantitatively about 0.8, 1.5, 0.3 and 1.4 quantity of labour, fuel, credit and ice blocks respectively are capable of producing a unit increase in the level of fish caught by the fisherfolks. The estimate of sigma – square (s^2) and gamma (γ) are also significant at 5% level while log likelihood function is estimated to be 60.9939. The estimate of λ (3.28) is large and significantly different from zero at 5%, thus indicating a good fit and correctness of the specified distribution assumption. For the MPF operators, only labour (f_l) and fishing experience (f_f) are determinant variables at 1% and 5% level respectively. But for the MF operators, fuel (f_f) and education (f_e) are significant factors at 5% level. During wet season, fishing time (f_t), fishing experience (f_f) and pollution are significant variables that determine the fish catch at different levels across the two fishing technologies. Only pollution is however significant at 10% level for the MPF operators. Fuel cost (f_c), cost of fishing losses (f_l) and extension (f_e) are significant at 5% and 1% level for the MF operators. Strict compliance with the implementation of the recommended policies will help to increase fish production level of the artisanal fishers and the general household income of the fisherfolks in the study area. By this, the level of fish protein intake among the people of fishing communities and indeed the whole of the state will increase. Rather than using hard-earned foreign exchange to import fish, it could be used to import inputs that will enable Nigeria produce its own supply of fish and eventually enhance the protein intake level of the citizenry.

Key words: Capture fisheries, variations, technologies, catch levels

INTRODUCTION

Lagos State is one of the eight maritime states in Nigeria. It produced 10.1 percent to 17.5 percent of the total fish output in the maritime states between 1985 and 1994[14]. It was observed that between 40 and 45 percent of the rural work force of the state engage in small-scale (artisanal) fisheries.

According to Lagos State Agricultural Development Authority (LASADA) artisanal fishing in the state is divided into three zones: Western, Eastern and Far Eastern zones. There are sixteen (16) blocks in the three (3) fishing zones and each block is divided into eight (8) circles. Each circle is being overseen by an extension officer who later divided each circle into 8 sub-circles called villages for monitoring convenience. Most of these fishing villages are found in coastal communities and adjoining waters in the state. Several studies had been conducted on the fishing activities of Lagos State. For example, Idowu et al[16], in a study on
the effects of tariffs and increased credit facilities on the fishing activities of the fisherfolks in Lagos State found out that increased access to credit facilities and a marginal reduction in the tariffs paid on the imported fishing inputs largely enhanced level of investment in artisanal fishery sub-sector in the state.

Each fisherfolk in the state employs two or more fishing gears depending on the season. Generally, artisanal fisherfolks of Lagos State experience serious economic constraints, which have forced them back to using traditional gears. But these fishing gears and equipment are very expensive with the prices varying from one fishing settlement to the other. The closer the settlement is to the urban centre, the cheaper the price. According to[18] the investment costs of fishing gears in Lagos state were highest (N51,000) for nets and least (N3,400) for floats and twines.

The study conducted by LASADA[13] showed that small-scale fisherfolks in Lagos State have access to all its 180km coastline, ranging as far out as their crafts permit within Nigeria’s 30 nautical mile territorial sea. The target fisheries in Lagos State are fresh and brackish water and marine, seasonally exploiting Sardinella maderensis, bonga, Ethmalosa fimbriata, Clupeid, Pellonula afzeliusi, large Sharks and rays, Chrysichthys nigrodigitatus; Tilapia spp; Gymnarchus niloticus and mud fish, Clarias spp etc.

The popular fishing crafts in Lagos are the Ghana dugout canoes with planked free boards. Smaller dug-out boats and planked canoes are sourced locally and the outboard engines are deployed in inland and marine fisheries.

However, craft motorization is facing some difficulties in terms of accessibility and adoption by the local fisherfolks[13]. To increase and maintain fish catch at high levels needs higher investment by both private and public entreprenuers in the sub-sector now and in years to come.

Fish catch levels in the Lagos artisanal fisheries vary across seasons, zones and technology. This is particularly so because of the differing determinants of fish catch levels. Oloamola[20] stated that fish catch level depended not only on resource abundance, but also on the fisherfolk’s quantity and type of gear, size and type of boat, type of boat propulsion and fishing skills. He added that the Nigerian fisherfolks used three fishing techniques: bonga or ring netting, bottom-set netting and shrimping. It was however, added that bottom - set netting offers a better chance of catching different types of fish. In another vein, Oloamola[20] while estimating the catch function for each season to determine whether resource productivity varied seasonally found out that the variables in the estimated functions explained 19% of the variations in catch for the wet-season model and 78% for the dry-season model. Hired labour and age were the significant explanatory variables for the wet-season model; fuel and family labour significantly explained variations in catch during the dry season. However, family labour was found to be negatively related to catch, thus indicating over use of this input. It was also noted that the factor inputs, except for fuel, tended to be more productive in the wet season than in the dry season.

Writing on seasonality and fish catch levels in artisanal fisheries in Lagos State, Lagos State Agricultural Development Authority, LASADA[13] stated that in both the sea and lagoons, seasonal fish abundance was significantly marked. Sardinella spp and Ethmalosa fimbriata, for example are abundant between late October / early November and April/May, peaking from late January through to February. Marine fisheries have been reported[19] to be more productive in the dry season. During the wet season (particularly between July and September) most fisherfolks shirk fishing because the sea is usually rough and turbulent for fishing activities. Lagoon fisheries are also more productive during the dry season. The major exceptions are the rivers and flood plain fisheries between late May and October targeting Macrbrachium spp., and Chrysichthys nigrodigitatus. The marked seasonality of fisheries targets and output, and the consequent prolongation of the slack time, indicate and make time for enterprise combination. Fisherfolks are generally less busy at a particular period of the year when fishing activities are at low ebb. This usually occurs when the water level is too high at the peak of the rainy season and during intense dry season when water level is extremely low. At such times fisherfolks try to look for other means of survival. They therefore engage themselves in food crop farming, lumbering, hunting and other activities that can keep them busy in the meantime.

Objectives of the Study: The broad objective of this study is to investigate the factors that determine the rate of fish catch in artisanal fishing of Lagos State. The specific objectives are to:

- find out the determinants of the use of a fishing technology among the artisanal fisherfolks;
- identify the factors that influence fish catch level across the zones and seasons;

Working Hypotheses For The Study: The following Hypotheses were tested:

1. $H_0$: There is no significant difference in the effects of socio-economic variables on fish catch level across fishing technologies;
2. $H_1$: There is significant difference in the effects of socio-economic variables on fish catch level across fishing technologies;
• \( i.e. H_0: \beta_1 = \beta_2 = \ldots = \beta_n = 0 \)
• \( H_1: \beta_1 \neq \beta_2 \neq \ldots \neq \beta_n \neq 0 \)

Where \( \beta_i \) refer to the vector of the parameters that determine the fish catch level by artisanal fisher folks.

2. \( H_o: \) There is no difference between the identified variables’ influence on the use of a fishing technology by fisher folks.

• \( i.e. \quad i = \ldots = n = 0 \)

\( H_1: \) There is difference between the identified variables’ influence on the use of a fishing technology by fisher folks.

• \( i.e. \quad i \neq \ldots \neq n \neq 0 \)

Where \( \beta_i \) are the vector of the parameters that determine the use of motorized fisheries (MF).

Methodology:
Types and Sources of Data for this study: This study made use of both primary and secondary data. The primary data were collected through a survey and administration of sets of structured questionnaire on artisanal fisher folks in Lagos State. The primary data provided information on the socio-economic characteristics of the artisanal fishing households, their capture technology, their sources and accessibility to credit facilities, fishing input requirements and costs, investment possibilities and constraints, actual returns, labour requirements, accessibility to extension agents and so on.

These data were supplemented with the secondary data which were obtained from the publications of the Federal Department of Fisheries (FDF), Lagos State Agricultural Development Authority (LASADA), and Lagos State Ministry of Agriculture. Data were obtained to further provide information on domestic fish catch level and importation in Nigeria. Other sources of secondary information included Lagos State Department of Fisheries, Central Bank of Nigeria, (CBN), Federal Office of Statistics, (FOS) publications, textbooks, publications of the Nigeria Institute of Oceanography and Marine Research, (NIOMR), Lagos and other relevant materials (published and unpublished).

Sampling Techniques: For the purpose of this study a two-stage sampling technique was used in selecting the respondent fisher folks. There are three (3) distinct fishing zones in the State: Western, Eastern and Far – Eastern zones. The fishing zones and communities were identified with the assistance of Lagos State Agricultural Development Authority (LASADA) agricultural extension agents (AEAs). There are a total of 16 blocks comprising of 6 blocks in the Western zone and 5 blocks in each of the Eastern and Far Eastern zones. The first stage of sampling involved a random selection of three (3) fishing blocks from each of the three (3) identified fishing zones, thus giving a total of 9 blocks for the study. Then a total of forty – five (45) fisher folks using Manual Propulsion Fisheries (MPF) and forty (40) fisher folks using Motorized Fisheries (MF) technology were randomly sampled from each of the three zones. The samples were collected in proportion to size of fisher folks in the zones. The proportionality factor used is as follows:

• \( W = \frac{r}{R} \times S \)

Where,

\( W = \) number of the sampled fishing blocks,
\( r = \) number of registered fisher folks in each block;
\( R = \) summation of the registered fisher folks in all the sampled blocks;
\( S = \) desired number of fisher folks sampled per fishing technology (MPF = 45; MF = 40).

This thus gave a total of 255 respondents for the study. The data were collected between January and October, 2004.

However, fifteen (15) of the samples from MPF operators were not returned at all and another eighteen (18) from MF operators were rejected due to incomplete and inconsistent responses. Thus, only 222 samples, comprising of 120 samples from MPF operators and 102 samples from MF operators were available for proper analysis. The breakdown of the list of sampled fishing communities from each zone is given on Table 1.

Method of Data Analysis:
Probit Model: The probit model was used to identify the determinants of the use of motorized Fisheries (MF) against the less resourceful and traditional, manually -paddled boats MPF. The probit model which is a quantitative response model, made it possible to predict the likelihood of adoption and use decisions expected on their personal attributes\(^{12,5,4,11}\). In probit analytical technique, the probability of a fisher folks adopting the use of a fishing technology /innovation is defined in terms of an index or stimulus, which is unobservable. The cumulative normal distributions with zero mean and unit variance are used in transforming the index to the probability range as given by\(^{10}\). However, \(^{11}\)
stated that the general form of the univariate dichotomous choice model could be expressed as:

\[ P_i = P(y_i = 1) = F(\omega_i, \varepsilon_i) \]  
\[ P_i = P(y_i = 1) = \int_{-\infty}^{\infty} \frac{e^{-\frac{1}{2}x^2}}{\sqrt{2\pi}} \mathrm{d}x \]

(1)

(2)

Where, \( P = P(y = 1) \) is the probability of a fisherfolk adopting the use of motorized fisheries (MF). This expression is again a function of the vector of explanatory variables, \( \omega \), and the unknown parameter vector, \( \varepsilon \). Pi is the probability that the \( i \)th fisherfolk chooses to use motorized fisheries (MF): \( y = 1 \) and \( y = 0 \) if otherwise. This is because these fisherfolks vary in the critical or threshold levels over a range for which they use a particular practice. It was further stated that probit analysis was a procedure that takes account of heteroscedasticity of the disturbance as well as restricting predictions to values between 0 and 1 by monotonically transforming the original model. The expression is stated in model (3):

\[ w_i = \eta_0 + \eta_1 y_1 + \ldots + \eta_6 y_6 + \eta_7 D_1 + \eta_8 D_2 + \eta_9 D_3 + \varepsilon_i \]

(3)

where

\( w_i \) = probability of a fisherfolk using a technology (users of motorized engine = 1; otherwise = 0)

\( y_4 \) = Fishing Distance (NM)
\( y_5 \) = Household Size (No.)
\( y_6 \) = weekly fish catch quantity (N)
\( y_7 \) = available credit facilities (N)
\( y_8 \) = number of contacts with extension agents/week
\( D_1 \) = Pollution level of fishing medium (Dummy: low=1; otherwise=0)
\( D_2 \) = Level of Risk (Dummy: low=1; otherwise=0)
\( D_3 \) = Gender of fisherfolk (Dummy: male=1; otherwise=0)
\( \varepsilon_i \) = error term
\( \eta_0 \) = constant term

\( \eta_1, \ldots, \eta_9 \) = regression co-efficients (parameters). The reported co-efficient estimates are the asymptotically unbiased and efficient point estimates to be used here. The corresponding standard error to these co-efficient usually measures the likely variation in the estimated co-efficient that may arise from sample to sample. The sign on the constant term can also give some hints on the interpretation of the result. A positive value means that there is a bias towards the dependent variable i.e. probability of the use of a particular fishing technology by a fisherfolk while a negative value is a bias away from it.

The Stochastic Frontier catch Model: This model was used to determine the level of technical, allocative and economic efficiency in both the Manual Propulsion Fisheries (MPF) and Motorized Fisheries (MF) across technologies, zones and seasons in Lagos State. Following [11], the fisherfolk’s frontier catch function written below is basically assumed:

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**Table 1:** List of Sampled Fishing Communities

<table>
<thead>
<tr>
<th>Zone Block</th>
<th>Fishing Technology</th>
<th>Sampled Fishing Communities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Badagry</td>
<td>15</td>
<td>Yovoyyan; Ago-Hausa; Akarakumo; Kotopa.</td>
</tr>
<tr>
<td>Ojo</td>
<td>15</td>
<td>Ikuata; Iwe; Ojo; Iyagbe.</td>
</tr>
<tr>
<td>Ibesi</td>
<td>15</td>
<td>Ibesi; Imore; Igbolohan; Okeogbe</td>
</tr>
<tr>
<td>Eastern Ikorodu</td>
<td>15</td>
<td>Borodu; Alaguntan; Ilado; Okunaju.</td>
</tr>
<tr>
<td>Agbowa</td>
<td>15</td>
<td>Agbowa; Ado; Oke-Lisa; Impe.</td>
</tr>
<tr>
<td>Imota</td>
<td>15</td>
<td>Imota; Ighopa; Igbore; Ason.</td>
</tr>
<tr>
<td>Far Eastern Ibeju-Lekki</td>
<td>15</td>
<td>Akodo-waya; Lepia; Lekki; Igando; Makbon - Alade.</td>
</tr>
<tr>
<td>Eti-Osa</td>
<td>15</td>
<td>Ikate Elegushi; Maroko; Okeogbe; Ikoyi.</td>
</tr>
<tr>
<td>Epe</td>
<td>15</td>
<td>Orimedu; Eleko; Osuokun; Siye.</td>
</tr>
<tr>
<td>Total</td>
<td>135</td>
<td>120</td>
</tr>
</tbody>
</table>

Where $Q$ is the quantity of fish catch, $x_j$ is the vector of input quantities, and $b$ is a vector of parameters. Eq. (4) is solved simultaneously to derive the technical efficiency $x_*$ for a given level of catch ($Q$), using the following input ratios:

$$\frac{x_i}{x_j} = k_i \quad (i > 1),$$

where $k_i$ is the ratio of observed inputs $x_i$ and $x_j$ at output $Q$. If the functional form of the catch frontier is self-dual, (e.g., Cobb-Douglas), then the corresponding cost frontier can be derived analytically and written in general form as:

$$C = h(k, Q, \alpha)$$

(5)

Where $C$ is the minimum cost associated with the catch level of $Q$, $h$ is the translog function, $k$ is the vector of input prices, $\alpha$ is the vector of parameters. By using Shephard’s Lemma, equation (5) above becomes

$$\frac{\delta C}{\delta k} = x_j(k, Q)$$

(6)

which is a system of minimum cost input demand equation. Substituting a fisherfolk’s input prices and quantity of fish catch into the demand system in equation (6) yields the economically efficient input vector $x_*$. Given a fisherfolk’s observed level of fish catch, the corresponding technically and economically efficient costs of fish catch are equal to $x_*k$ and to $x'_*k$ respectively, while the cost of the fisherfolk’s actual operating input combination is $X_*k$. These three cost measures are the bases for computing the following technical (TE) and economic efficiency (EE) indexes:

$$TE = \frac{(x'_*,k)}{(X'_*,k)}$$

(7)

and

$$EE = \frac{(x'_*,k)}{(X_*k)}$$

(8)

Finally, allocative efficiency (AE), derived from equations (7) and (8) above is given by

$$AE = \frac{EE}{TE} = \frac{(x'_*,k)}{(x'_*,k)}$$

(9)

The fishing enterprise, technical efficiency (TE) of the $j$th fisherfolk was estimated by using the expectation of $U_j$ conditions on the random variable $\varepsilon_j$ as shown by (10), i.e.

$$TE_j = \exp. (-U_j)$$

(10)

So that $0 \leq TE_j \leq 1$. Similarly, Allocative efficiency of the $j$th fisherfolk (AE) is given by:

$$AE_j = \exp. (-V_j)$$

(11)

So that $0 \leq AE_j \leq 1$

To empirically measure efficiency, a stochastic catch frontier model is firstly estimated, and then followed by the approach introduced by (17) to separate the deviations from the frontier into a random and an efficiency component. To show how this separation is accomplished, the stochastic catch frontier was used thus:

$$Q = f(x_\varepsilon; \beta)\varepsilon_j$$

Where $\varepsilon_j = v_j - u_j$

(12)

is the decomposed error term (14). The two components $v_j$ and $u_j$ are assumed to be independent of each other, where $v_j$ is the two-sided, normally distributed random error ($v \sim N(0, \sigma^2)$), and $u_j$ is the one-sided efficiency component with a half-normal distribution ($u \sim N(0, \frac{\sigma^2}{2})$).

The maximum likelihood estimation of equation (13) yields estimation for $\beta$ and $\lambda$, where $\beta$ was defined earlier, $\lambda = ou/ov$ and $\sigma^2 = ou^2 + ov^2$.

But assuming a half-normal distribution of $u_j$, (17) suggested the estimation of the conditional mean of $u_j$ given $\varepsilon_j$ as:

$$E(u_j|\varepsilon_j) = \sigma \frac{f^*(\varepsilon_j \lambda/\sigma)}{f^*(\varepsilon_j \lambda/\sigma) - \varepsilon_j \lambda}$$

where,$$f^*$$

(14)

and $F^*$ and $f^*$ are respectively the standard normal density and distribution functions, evaluated as $\varepsilon \lambda/\sigma$ and $\sigma^2 = \sigma^2 x \sigma^2/\sigma^2$. Equations (9) and (11) thus provide the estimates for $u$ and $v$ after replacing $\varepsilon, \sigma^2$ and $\lambda$ by their estimates. Subtracting $v$ from both sides of (14) gives

$$Q^* = f(x_\varepsilon) - u = Q - v$$

(15)

Where $Q^*$ is the fisherfolk’s observed catch level adjusted for the statistical disturbance captured by $v_j$. Equation (15) is the basis for computing the vector $x_\varepsilon$ and for algebraically deriving the cost frontier. Lastly, the application of Shephard’s Lemma to the cost frontier yields the minimum cost factor demand equations which, in turn, are used to obtain the vector $x_\varepsilon$. The use of the single – equation model depicted in equation (13) and (14) is justified by assuming that the fisherfolks maximize expected profit. This has been done in similar studies.[18,10,7,22,17]

For the purpose of this study, the specific estimated Cobb-Douglas model, written explicitly, is as follows:

$$Q = x_\varepsilon f_\varepsilon$$

(16)
In $Q_{ij} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + V_{ij} - U_{ij}$

(16)

where,

$Q_{ij} = \text{Quantity of fish catch per fisherfolk per week (kg)}$

$X_1 = \text{Labour used per fisherfolk/week (hrs).}$

$X_2 = \text{Quantity of fuel used per fisherfolk/week (litres) for fishing.}$

$X_3 = \text{Credit used per fisherfolk/week (₦).}$

$X_4 = \text{Quantity of Baits used for fishing per week (₦).}$

$X_5 = \text{Quantity of ice blocks used per fisherfolk per week (kg).}$

- $\beta_i$ and $V_{ij}, U_{ij}$ are as earlier defined. $\ln = \text{natural logarithm}$

The functional form stated in equation (16) above did not reflect seeding/stocking” in the specification of the relevant variable inputs since the fisherfolks only harvest the aquatic media in which they operate. These media are open access resources with unlimited chances of use to members of the public. The a priori expectation is that all the independent variables ($x_1, \ldots, x_5$) above should have a positive relationship with the quantity of fish catch per fisherfolk per week.

**Cobb-Douglas Cost Frontier Model:** The corresponding (dual) Cost frontier model, written explicitly is given as:

$$\ln C_i = \Phi_0 + \Phi_1 Q_{ij} + \Phi_2 c_1 + \Phi_3 c_2 + \Phi_4 c_3 + \Phi_5 c_4 + \Phi_6 c_5 + V_{ij} - U_{ij}$$

(17)

Where,

$C_i = \text{Total cost of catching 1 kg of fish per fisherfolk}$

$Q_{ij} = \text{Quantity of fish catch per fisherfolk per week (kg)}$

$c_1 = \text{Wage rate per hour of labour (₦).}$

$c_2 = \text{Price per litre of fuel (₦).}$

$c_3 = \text{Cost of credit used (₦).}$

$c_4 = \text{Price per unit of baits (₦/kg).}$

$c_5 = \text{Price per unit of ice blocks (₦/kg).}$

$\Phi_i = \text{Parameters to be estimated.}$

$V_{ij}, U_{ij}$ are as earlier defined.

$j = \text{ith observation}$

$i = \text{ith fisherfolk}$

Note: $X_1$ and $C_2$ do not apply to the MPF operators as they do not consume fuel in their operations.

The a priori expectation is that all the independent variable ($c_1, \ldots, c_5$) should have a positive relationship with the total cost of catching 1kg of fish. The stochastic frontier catch model was used to fit the three (3) fishing zones separately; using maximum likelihood procedures. The estimated Cobb-Douglas catch frontier is the basis for deriving a stochastic cost frontier and related efficiency measures\(^9\). This is because the stochastic catch function is self-dual. This functional form has been widely used in farm efficiency analysis for both developing and developed countries\(^9\).

**Tests of Hypotheses:** Here, the statistical instrument used was t-test. T-test was used to ascertain the level of significance of each of the estimated parameter coefficient of the independent variables at the various levels of significance. To proceed with the t-test, the null hypotheses ($H_0$) and the alternative $H_1$ are stated as:

$H_0: \beta_i = \beta_2 = \ldots = \beta_n = 0$

$H_1: \beta_i \neq \beta_2 \neq \ldots \neq \beta_n$ \(≠ 0\)

The null hypothesis was then tested against the alternative for each of the estimated parameters of the model using:

$$t_{st} = \frac{\beta_i}{\sqrt{\sum E_{\beta i}}}$$

(18)

$t$ – has a standard normal distribution. The value of $t$, obtained from the formula above is then compared with the tabulated value of $t_\alpha$, df., where $\alpha$ is the level of significance. The decision rule is

- $H_0$: is rejected if and only if $|t_{st}| > t_\alpha$, at the stated level of significance given the degree of freedom.
- $H_1$: is accepted if and only if $|t_{st}| \leq t_\alpha$, at the stated level of significance given the degree of freedom.

**RESULTS AND DISCUSSIONS**

**Determinants of the Use of a Fishing Technology among Artisanal Fisherfolks:** The probit model was used to identify the determinants of the use of motorized (modern) fishing technology among artisanal fisherfolks in Lagos state. In the probit analysis 6 complete iterations were done for the convergence of the model. The parameter estimates are presented in Table 2 and the restricted version is shown in Table 3.

The likelihood ratio test indicates that the model, as specified, explained significant non-zero variations in factors affecting the use of motorized fisheries (MF). Parameter estimates for the model were evaluated at
Fishermen could also increase the likelihood of their credit facilities for the use of the artisanal into the water to make good catches. The availability of credit facilities for the use of the artisanal fishermen could also increase the likelihood of their fishing distance, catch level, available credit facilities, and the alternative hypothesis upheld.

Educated fishermen have greater likelihood to understanding the working mechanism of the motorized engines and therefore should be able to use it more than illiterate class of fishermen. Fishing distance is another important variable that could determine the use or (otherwise) of motorized fisheries technology among the artisanal fishermen of Lagos state. Fishermen generally want to reach out far into the water/sea to be able to make good catches. This is important because the nearby coastal waters are usually over-exploited and therefore depleted. Again, the target of increasing fish catch level by the fishermen could also make them abandon the manually paddled canoes and adopt the use of modern outboard engines that reach out far into the water to make good catches. The availability of credit facilities for the use of the artisanal fishermen could also increase the likelihood of their adopting the use of outboard engines as against the use of traditional, manual-propelled boats/canoes. The credit facilities will enable the fishermen to acquire the fishing machines that are capable of reaching far into distant waters and thus increase the fish catch levels of the artisanal fishermen.

The higher the number of contacts with the extension agents, the more the likelihood of fishermen to be properly informed/educated on the relevance and importance of the outboard engines, and thus, their probability of using them. Finally, the gender of the artisanal fishermen, often determines the likelihood of use of the outboard engines. Male fishermen are more likely to use the modern (motorized) fishing machines than the risk-averse female counterparts[1]. This is because female fishermen feel more comfortable fishing in the coastal water, for security reasons, as against fishing in the far turbulent deep sea waters.

### Table 2: Probit Parameter Estimates of the use of motorized (modern) Fishing Technology (n = 222)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>Std. Error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (γ1)</td>
<td>0.3214</td>
<td>0.7502</td>
<td>0.4284</td>
</tr>
<tr>
<td>Experience (γ2)</td>
<td>0.6514</td>
<td>0.7431</td>
<td>0.8766</td>
</tr>
<tr>
<td>Education (γ3)</td>
<td>1.4468</td>
<td>0.8618*</td>
<td>1.6788</td>
</tr>
<tr>
<td>Fishing Distance (γ4)</td>
<td>0.8365</td>
<td>0.4115**</td>
<td>2.033</td>
</tr>
<tr>
<td>Household size (γ5)</td>
<td>-0.8816</td>
<td>0.9983</td>
<td>-0.8831</td>
</tr>
<tr>
<td>Catch level (γ6)</td>
<td>0.7934</td>
<td>0.3001***</td>
<td>2.6438</td>
</tr>
<tr>
<td>Credit facilities (γ7)</td>
<td>1.1134</td>
<td>0.6374*</td>
<td>1.7468</td>
</tr>
<tr>
<td>Extension (γ8)</td>
<td>2.4628</td>
<td>1.4919*</td>
<td>1.6508</td>
</tr>
<tr>
<td>Pollution (Dummy low = 1; otherwise = 0)</td>
<td>-1.6341</td>
<td>1.8304</td>
<td>-0.8728</td>
</tr>
<tr>
<td>Risk level (Dummy low = 1; otherwise = 0)</td>
<td>-0.7462</td>
<td>2.6141</td>
<td>-0.2855</td>
</tr>
<tr>
<td>Gender (Dummy: male = 1; otherwise = 0)</td>
<td>0.1712</td>
<td>0.1031*</td>
<td>1.6605</td>
</tr>
<tr>
<td>Intercept</td>
<td>-3.7161</td>
<td>2.6054</td>
<td>-1.4528</td>
</tr>
</tbody>
</table>

***Significant at 1% level.
**Significant at 5% level.
*Significant at 10% level.

### Table 3: Restricted Probit Parameter Estimates of the use of motorized (modern) Fishing Technology (n = 222)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>Std. Error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education (γ1)</td>
<td>1.4468</td>
<td>0.8618*</td>
<td>1.6788</td>
</tr>
<tr>
<td>Fishing Distance (γ2)</td>
<td>0.8365</td>
<td>0.4115**</td>
<td>2.033</td>
</tr>
<tr>
<td>Catch level (γ3)</td>
<td>0.7934</td>
<td>0.3001***</td>
<td>2.6438</td>
</tr>
<tr>
<td>Credit facilities (γ4)</td>
<td>1.1134</td>
<td>0.6374*</td>
<td>1.7468</td>
</tr>
<tr>
<td>Extension (γ5)</td>
<td>2.4628</td>
<td>1.4919*</td>
<td>1.6508</td>
</tr>
<tr>
<td>Gender (Dummy: male = 1; otherwise = 0)</td>
<td>0.1712</td>
<td>0.1031*</td>
<td>1.6605</td>
</tr>
<tr>
<td>Intercept</td>
<td>-3.7161</td>
<td>2.6054</td>
<td>-1.4528</td>
</tr>
</tbody>
</table>

***Significant at 1% level.
**Significant at 5% level.
*Significant at 10% level.

### Table 4: Maximum Likelihood Estimate (MLE) of Stochastic catch frontier for fisherfolks across technologies

<table>
<thead>
<tr>
<th>Variable</th>
<th>MPF</th>
<th>MF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.1766**</td>
<td>2.4850***</td>
</tr>
<tr>
<td>(2.2209)</td>
<td>(3.789)</td>
<td></td>
</tr>
<tr>
<td>Labour (x1)</td>
<td>0.7825***</td>
<td>0.7843***</td>
</tr>
<tr>
<td>(2.6698)</td>
<td>(5.9077)</td>
<td></td>
</tr>
<tr>
<td>Fuel (x2)</td>
<td>-</td>
<td>1.4528***</td>
</tr>
<tr>
<td>(4.4088)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Credit (x3)</td>
<td>0.0428</td>
<td>0.2770**</td>
</tr>
<tr>
<td>(0.2027)</td>
<td>(2.4145)</td>
<td></td>
</tr>
<tr>
<td>Baits (x4)</td>
<td>0.3612***</td>
<td>0.7385</td>
</tr>
<tr>
<td>(2.8310)</td>
<td>(1.780)</td>
<td></td>
</tr>
<tr>
<td>Ice Blocks (x5)</td>
<td>0.0712</td>
<td>1.3851**</td>
</tr>
<tr>
<td>(1.250)</td>
<td>(2.4123)</td>
<td></td>
</tr>
<tr>
<td>λ</td>
<td>2.56**</td>
<td>3.28**</td>
</tr>
<tr>
<td>2.21</td>
<td>2.16</td>
<td></td>
</tr>
<tr>
<td>Gamma γ</td>
<td>0.9874***</td>
<td>0.4598**</td>
</tr>
<tr>
<td>(38.13)</td>
<td>(2.5552)</td>
<td></td>
</tr>
<tr>
<td>σ1^2 = σ2^2 + σγ^2</td>
<td>0.0381***</td>
<td>0.0261**</td>
</tr>
<tr>
<td>(3.6943)</td>
<td>(2.1631)</td>
<td></td>
</tr>
<tr>
<td>Log likelihood function</td>
<td>46.4934</td>
<td>60.9939</td>
</tr>
</tbody>
</table>

***Significant at 1% level.
**Significant at 5% level.
The effect of the variables such as experience, household size, pollution of the aquatic media, and fishing technology risk level were not significant in the probability of fisherfolks’s use of modern (motorized) engines. Household size, pollution of aquatic media and fishing technology risk level recorded a negative relationship with the probability of the use of outboard (modern) engines by the artisanal fisherfolks. All other variables, however, had positive relationship with the probability of the use of motorized engines. The negative sign on the household size may be ascribed to the low level of assistance received by the fisherfolks from the other household members, as well as the high consumption pressure imparted by them on the fisherfolks’s income. This also, probably explains the negative relationship observed between the pollution of aquatic media and the risk level of the fishing technology and the probability of the use of motorized (outboard) engines by the artisanal fisherfolks of Lagos state.

Technical, Allocative and Economic Efficiency Estimates:

Effect of determinant variables on fish catch level according to technologies: The maximum likelihood estimates (MLE) of Stochastic catch frontier was done. This activity was conducted separately for the artisanal fisherfolks practising Manual Propulsion Fisheries MPF and those practising the Motorized fisheries (MF) (Table 4).

The estimated stochastic catch frontier (MLE), using frontier (version 4.1) package, are given as:

\[
\begin{align*}
\text{MPF: } \ln Q_{ij} &= 1.1766^{**} + 0.7825^{***} \ln x_j + 0.0428 \ln x_i \\
&+ 0.3616^{***} \ln x_j + 0.0712 \ln x_i \\
&+ 0.0428 \ln x_i (19) \\
&+ 0.3616 (2.8310) \\
&+ 0.0712 (1.250)
\end{align*}
\]

\[
\begin{align*}
\text{MF: } \ln Q_{ij} &= 2.488^{***} + 0.7843^{***} \ln x_j + 1.4527^{***} \ln x_i \\
&+ 0.3616^{***} \ln x_j + 0.0712 \ln x_i \\
&+ 0.3616 (2.488) \\
&+ 0.0712 (1.250)
\end{align*}
\]

In Table 4., the MLE of Stochastic catch frontier was presented for both MPF and MF. For the MPF operators both labour \((x_i)\) and bait \((x_j)\) are positively significant at 1% level. The estimates of the sigma square \((\sigma_i^2)\) and gamma \((\gamma)\) are positively significant at 1% level, while the log likelihood function maintained a fairly large value (Table 4.). The estimate of \(\lambda(2.56)\) was large and significantly different from zero at 5%, thus indicating a good fit. It was also noted that the signs of all the variables agreed with the \textit{a priori} expectations.

Also, in Table 4, the estimate of the Maximum Likelihood (ML) of Stochastic catch frontier for Motorized fisheries, MF, (artisanal) in Lagos State is presented. For the ML catch frontier for MF labour \((x_i)\) and fuel \((x_j)\) are positively significant at 1% level while credit \((x_k)\) and ice block \((x_l)\) are significant at 5% level. Quantitatively about 0.8, 1.5, 0.3 and 1.4 quantity of labour, fuel, credit and ice blocks respectively are capable of producing a unit increase in the level of fish caught by the fisherfolks. The estimate of sigma – square \((\sigma_i^2)\) and gamma \((\gamma)\) are also significant at 5% level while log likelihood function is estimated to be 60.9939. The estimate of \(\lambda(3.28)\) is large and significantly different from zero at 5%, thus indicating a good fit and correctness of the specified distribution assumption.

The estimates of ML of Stochastic cost frontier for MPF and MF operators (artisanal) in Lagos State are presented in Table 5.

This dual cost frontier was derived analytically from the catch frontier function. ML cost frontier estimates for the MPF indicated that wage \((c_i)\), credit \((c_k)\) and ice blocks \((c_l)\) are positively significant at 1% level. Quantitatively about 0.5, 0.1 and 1.3 marginal increases in the quantity of wage rate, cost of credit and cost of ice blocks respectively could produce a unit increase in the total cost of fish catch by the fisherfolks per week. All the variables, \(c_i\), \(c_k\) and \(c_l\) again possessed the correct signs that agreed with \textit{a priori} expectations. The parameter estimates for sigma-square \((\sigma_i^2)\) and gamma \((\gamma)\) are however not significant at all. The dual cost frontiers, derived analytically from the catch frontiers (MLE) are given as:

\[
\begin{align*}
\text{MPF: } \ln C &= 2.2851^{***} - 0.046\ln Q_{ij} + 0.4981^{***}\ln c_i \\
&+ 0.1332^{***}\ln c_i + 0.0934\ln c_i + 1.3463^{***}\ln c_i \\
&+ 0.9123^{***} \ln c_l + 1.3463^{***} \ln c_l \\
&+ 1.4527^{***} \ln c_l + 0.0934 \ln c_l
\end{align*}
\]

\[(21)\]

Table 5: Maximum Likelihood (ML) Estimates of Stochastic cost frontier for Fisherfolks across technologies

<table>
<thead>
<tr>
<th>Variable</th>
<th>MPF</th>
<th>MF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>2.2851***</td>
<td>3.6113***</td>
</tr>
<tr>
<td>Output ((Q_i))</td>
<td>18.8851</td>
<td>5.1664</td>
</tr>
<tr>
<td>Wage ((c_i))</td>
<td>0.4981***</td>
<td>0.1960***</td>
</tr>
<tr>
<td>Fuel ((c_j))</td>
<td>-</td>
<td>-0.0999</td>
</tr>
<tr>
<td>Cost of credit ((c_k))</td>
<td>0.132***</td>
<td>0.0352</td>
</tr>
<tr>
<td>Cost of credit ((c_k))</td>
<td>1.3463***</td>
<td>0.9123</td>
</tr>
<tr>
<td>Cost of ice block ((c_l))</td>
<td>1.3463***</td>
<td>0.9123</td>
</tr>
<tr>
<td>Gamma (g)</td>
<td>236.302</td>
<td>221.036</td>
</tr>
</tbody>
</table>

Source: Computed from survey data, 2004

Figures in parentheses are \( t \) – values.

***Significant at 1% level.

**Significant @ 5% level.
The result of the Maximum Likelihood Estimate (MLE) had the correct signs that agreed with *a priori* expectations. The sigma square $\sigma^2$ is significant at 1% level and the value of log likelihood function is high, thereby implying a reasonable goodness of fit for the model.

**Effect of determinant variables on fish catch level according to seasons:** Various independent variables have been established\[^{20}\] to have influence on the fish catch level of artisanal fisherfolks on seasonal basis. The result of the Maximum Likelihood Estimate (MLE) of the stochastic catch frontier for fisherfolks across seasons is presented in Table 6:

During dry season fishing time ($f_i$), extension services ($f_j$) and pollution affect the quantity of fish catch across technologies at various levels of significance. For the MPF operators, only labour ($f_3$)
Table 7: Maximum Likelihood Estimate (MLE) of the stochastic catch frontier for fisherfolks across zones.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Fishing Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Western (n = 73)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.0364</td>
</tr>
<tr>
<td>Experience (z_i)</td>
<td>0.8441**</td>
</tr>
<tr>
<td></td>
<td>(2.1136)</td>
</tr>
<tr>
<td>Labour (z_i)</td>
<td>0.1367</td>
</tr>
<tr>
<td></td>
<td>(1.4726)</td>
</tr>
<tr>
<td>Capital Assets (z_i)</td>
<td>1.7228**</td>
</tr>
<tr>
<td></td>
<td>(2.4431)</td>
</tr>
<tr>
<td>Fishing gear (z_i) (Dummy: motorized = 1 otherwise = 0)</td>
<td>0.8931</td>
</tr>
<tr>
<td></td>
<td>(1.4315)</td>
</tr>
<tr>
<td>Education (z_i)</td>
<td>0.0582</td>
</tr>
<tr>
<td></td>
<td>(1.0789)</td>
</tr>
<tr>
<td>Extension (z_i)</td>
<td>1.6381***</td>
</tr>
<tr>
<td></td>
<td>(3.1451)</td>
</tr>
<tr>
<td>Season (z_i) (Dummy: dry = 1 otherwise = 0)</td>
<td>0.8641**</td>
</tr>
<tr>
<td></td>
<td>(2.4881)</td>
</tr>
<tr>
<td>Log likelihood function</td>
<td>36.744</td>
</tr>
<tr>
<td>[\sigma^2 = \sigma_i^2 + \sigma_u^2]</td>
<td>0.0738**</td>
</tr>
<tr>
<td></td>
<td>(2.6381)</td>
</tr>
<tr>
<td>[\lambda]</td>
<td>1.76**</td>
</tr>
<tr>
<td></td>
<td>(2.14)</td>
</tr>
</tbody>
</table>

Source: Computed from survey data, 2004

Figures in parentheses are t – values.

***Significant at 1% level.

**Significant at 5% level.

*Significant at 10% level.

and fishing experience (f_i) are determinant variables at 1% and 5% level respectively. But for the MF operators, fuel (f_i) and education (f_i) are significant factors at 5% level. During wet season, fishing time (f_i), fishing experience (f_i) and pollution are significant variables that determine the fish catch at different levels across the two fishing technologies. Only pollution is however significant at 10% level for the MPF operators. Fuel cost (f_i), cost of fishing losses (f_i) and extension (f_i) are significant at 5% and 1% level for the MF operators. The log likelihood functions are fairly large and lambda (\lambda) values are greater than 1 across technologies for the two seasons. This implies that the one sided error u_i dominates the symmetric error v_i. This signifies a good fit for the estimated models and the correctness of the distributional assumptions for the decomposed error term\[22\].

Effect of determinant variables on fish catch level according to zones: In Table 7 the effect of some independent variables on the fish catch level on zonal basis of the fisherfolks of Lagos State is presented. Fishing experience (z_i), capital assets (z_i), extension (z_i) and seasons (z_i) all have significant effect on fish catch of the fisherfolks at various levels across the three zones. Education (z_i) and type of fishing gear (z_i) are significant at 5% level for the Eastern and Far-eastern zones respectively. The log likelihood functions and the lambda values are greater than 1 across the three fishing zones. This again implies that the estimated models are of good fit and the distribution assumptions for the decomposed error term are correct\[22\].

Conclusion: This research has investigated the efficiency of artisanal fish catch technologies in Lagos State, Nigeria. The findings have confirmed the relevance of the adoption and the use of the modern fishing technology involving motorized boats by the artisanal fisherfolks to increase the fish catch level. This is important because it enables the artisanal fisherfolks to move away from the archaic and
traditional fishing system characterized by the use of energy-sapping, paddle-propelled boats/canoes that can only operate in the near coastal waters. The fishing distance of the fisherfolks needs to extend beyond the coastal waters that are already over-exploited and have suffered serious stock depletion. More fishing activities should be done in the distant waters with the aid of the outboard engines which can move faster and easier within short time. Indiscriminate capture of juveniles and brooders should however be checked as fisherfolks try desperately to increase their fish catch levels. Strict compliance with the implementation of the recommended policies will help to increase fish production level of the artisanal fishers and the general household income of the fisherfolks in the study area. By this, the level of fish protein intake among the people of fishing communities and indeed the whole of the state will increase. Rather than using hard-earned foreign exchange to import fish, it could be used to import inputs that will enable Nigeria produce its own supply of fish and eventually enhance the protein intake level of the citizenry.

**Recommendations:** Several findings have emerged from this study. These findings need to be utilized for a better performance of the artisanal fisherfolks in Lagos State. The following recommendations are therefore made towards enhancing the fish catch level and increasing the fortunes of the artisanal fisherfolks in the state.

The effects of risks suffered by the artisanal fisherfolks in terms of loss of fishing materials/equipment in fishing waters, spoilage of fish on delayed homeward journey, terrible storms at sea and lagoons could be absorbed by instituting insurance schemes for the registered artisanal fisherfolks in the state. This could be done with the full support of the co-operative societies to which these fisherfolks belong. As a matter of policy, all the significant variables that determine the use of a particular fishing technology by the artisanal fisherfolks should be properly addressed. Literacy among fisherfolks and credit facilities have positive effect on the use of motorized boats. These facilities could be made available by both co-operative societies, government, multilateral bodies and non-governmental organizations.

The result also indicates that fishing time and pollution of the aquatic media affect the quantity of fish catch across technologies for both dry and wet seasons. It is therefore recommended that the fisherfolks should fish for longer period on water so as to increase their fish catch level. The level of pollution of aquatic media determines the ease of movement on water by the fisherfolks’s boats/canoes. Water pollutants such as water hyacinth, chemicals, algal growth, domestic sewage and agricultural waste, detergent and pesticides could cause a lot of havoc to marine lives. Continued build-up of these pollutants in the marine eco-system can cause increased reproductive failures in many marine species of fish. It is therefore recommended that indiscriminate dumping of refuse and other waste materials particularly chemicals into the marine eco-system should be checked. Mechanical method of control of the menace of water hyacinths should be embarked upon so as to eliminate cases of clogging the meshes of bottom set gillnet.

**REFERENCES**


